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In this paper I will present the results from a small-scale research project undertaken with both a group of pre-Initial Teacher Education (ITE) Mathematics Enhancement Course (MEC) students and a group of Initial Teacher Education (ITE) Professional Graduate Certificate in Education (PGCE) students at the University of East London (UEL) between January 2008 and July 2009. The emerging results are in their early stages of development and are a continuation and development of the work addressed in two previous papers; one presented to the British Educational Research Association (BERA) conference in September 2008 (Clarke 2008a) and another presented to the British Society for Research into the Learning of Mathematics (BSRLM) conference in November 2008 (Clarke 2008b). The work appears to show some evidence that participation in a MEC, and hence exposure to a variety of teaching approaches, does change "beliefs" concerning the way in which participants think mathematics should be taught. Once changed, these changed "beliefs" appear to be robust.

Keywords: Mathematics; Beliefs; Teaching; Pre-Initial Teacher Education; Mathematics Enhancement Course; Subject Knowledge.

Introduction

In recent years, the *quality* of mathematics teaching has been a continuing focus of concern. A recent Ofsted report 'confirmed the narrow nature of much of the teaching' (Ofsted 2008, 5) of mathematics in schools, while an earlier report had, as one of its main conclusions that the 'quality of teaching was the key factor influencing students' achievement' (Ofsted 2006, 1). How can the 'quality' of our mathematics teaching in this country change?

As the programme leader of a pre-Initial Teacher Education (ITE) MEC, I have seen students exposed to a wide variety of teaching pedagogies which they had not previously experienced as learners. From discussion with the MEC 2007 cohort of students I was provided with anecdotal evidence that this exposure had impacted on their 'beliefs' concerning how they thought mathematics should be taught. I presented a paper to BERA in 2008 (Clarke 2008a) in an attempt to place my early anecdotal ideas in a more evidence based, critical framework. I felt, and still feel, that changing the beliefs of mathematics teachers will eventually impact on the 'quality' of mathematics teaching in the classroom.

It appears obvious that if you want teachers to teach in a less didactic way then their own learning of mathematics should be facilitated in a less didactic way. However, if it really was that easy there would be less didactic teaching of mathematics taking place in schools and less need for critical Ofsted reports.

Schoenfeld (1992) tells us that beliefs underpin personal thought and behaviour. Beliefs underlie reasons why we engage in certain practices and not others. However, beliefs can also become too comfortable and too resistant to change (Green, 1971; Rokeach, 1960). Swan (2006) pulled much of this work together and has indicated that any attempt to develop mathematical teaching practices must attend to the beliefs of mathematics teachers and to changes in these beliefs. Swan's work is primarily based on quantitative methods and has been aimed at in-service teachers; I've attempted to replicate some of his work with pre-service teachers and, in addition I'll be attempting to complement it using qualitative methods.

The essential question to be answered in this paper is: Does participation in a pre-ITE MEC, and hence exposure to a variety of teaching approaches, change the 'beliefs' of pre-ITE students concerning the way in which they think mathematics should be taught? In addition, once changed, are these new beliefs robust? My evidence leads me to tentatively say 'yes', but with various qualifying statements.

The Study

My research method was mostly a quantitative approach and had three elements:

1. Collect quantitative data from MEC students via two identical questionnaires during the 2008 MEC course, then analyse the difference in response. I have already presented the results of this study (see Clarke 2008a, 2008b).
2. Collect quantitative data from 6 of the now ex-MEC students from the 2008 study, when they were half way through their ITE PGCE in 2009. This allows the data sets to be analyzed from both a cross-sectional basis and a longitudinal/panel basis.
3. In addition, I collected qualitative data in the form of written responses to four statements concerning teaching which the students had observed and/or taken part in during the PGCE; I also administered these statements to a further 11 none-MEC PGCE.

As Thompson (1992) notes, most research into beliefs is interpretative and uses qualitative methods. Here I followed some of the qualitative work of Swan (2006) and will be attempting in future to complement it with approaches using qualitative data. It is hoped that the emerging results will eventually provide insight into the relationship for a trainee mathematics teacher between prior experience of pedagogy as a learner, current experience of pre-ITE pedagogy in a transition phase from learner to teacher and future beliefs about their pedagogy as a teacher.

In 2008 I collected 20 paired data responses to the two questionnaires from the 2008 MEC cohort. The questionnaire consisted of 25 statements on teaching practices which the participants had to express a 'belief' in (scored 1 to 5 on a Likert scale). The 'belief statements' used to form the questions in the questionnaire were based upon statements previously used by Swann (2005) and the Standards Unit (2005) and are listed elsewhere (Clarke 2008, 3-4). The first time the participants filled in the questionnaire was on day-1 of the MEC and the second time was on the very last day of the MEC. I did not discuss the research with any of the participants between these occasions. In addition I collected data on the group concerning gender, age range, the highest qualification obtained in mathematics and their 'place of origin'. For the 'place of origin' I asked for the country and continent where they received the majority of their secondary school teaching aged 11-16.

In 2009 I followed up 6 of the original 20 ex-MEC students during their 2008/2009 PGCE course at UEL and administered the questionnaire for a third time to them. I also collected written responses to four statements concerning teaching which they had observed and taken part in. In addition, I administered the questionnaire and statements to a further 11 none-MEC PGCE students on the 2008/2009 PGCE course. The four statements were:

- I see most maths teachers using didactic teaching methods in observations of maths lessons.
- I see a good range of teaching methods and strategies in observations of maths lessons.
- I teach most of my lessons using basically didactic teaching methods.
- I teach most of my maths lessons using a good range of teaching methods and strategies.

My 2008 Findings

I am aware of the disadvantages of using Likert scales (Forrester 2008, 27) and the problems of effectively treating ordinal scaled data as a continuous ratio scale for the purposes of my statistical analysis. However, to paraphrase Rorty (1994, 59) I am attempting to obey 'the normal conventions of (my) discipline', while 'not fudging the data too much' but also 'not blocking the road to enquiry.' In other words, I know that my statistical work is not entirely robust, but I will continue to analyse it pragmatically.

During the 2008 study, there were 500 possible changes in belief (20 students x 25 statements). 240 responses (48%) showed no change in beliefs. Of those responses which represented a change in belief 160 (32%) were positive changes representing a change towards a less didactic approach to teaching and 100 (20%) were negative changes representing a change towards a more didactic approach to teaching. At this basic level the evidence leads me to tentatively state that participation in this pre-ITE MEC, and hence exposure to a variety of teaching approaches, had changed the 'beliefs' concerning the way students think mathematics should be taught. In addition the beliefs of the participants appear to have changed away from didactic teaching towards less didactic teaching.

This change was not a *strong* change and it is not consistent throughout the statements. Some statements have much more change than others and some statements even have relatively strong negative changes. For example statement 10 (I believe I need to teach each maths topic separately), statement 18 (I believe I should jump between topics as the need arises) and statement 19 (I believe I should find out which parts learners already understand and don't teach those parts) exhibited strong positive change for half the group. These may be 'beliefs' which are easily changed in the context of the students themselves being learners. While statement 1 (I believe Learners should start with easy questions and work up to harder questions), statement 5 (I believe Learners learn maths through doing maths exercises) and statement 22 (Even though I'll plan my lessons thoroughly, I believe I'll be constantly surprised by the ideas that come up during my lessons) exhibited very little change. Many of these beliefs were already at the top end of my scale and therefore difficult to exhibit more positive change. It was interesting that statement 6 (I believe I should try to cover *everything* in a topic) exhibited a negative change in 50% of the group. This is causing me to return to my interpretations of which statements display belief bias towards didactic or non-didactic type teaching.

I analysed the 2008 data by age, sex, geographic origin and highest qualification in mathematics. It was not possible to identify a strong correlation of age to belief change. However, in this particular group the older participants did exhibit more change away from didactic teaching. There does appear to be *some* gender difference in belief change and *some* in belief change correlated with geographical origin. Europeans did appear to have a much stronger move away from didactic beliefs than those of African origin, however females made up 29% of the African group and 55% of the European group; so this variation in belief changes may be due to a gender effect rather than a 'place of origin' effect. A very interesting feature of the data was the lower the highest qualification in mathematics attained by the participants prior to MEC the stronger the move away from didactic beliefs.

My 2009 Findings

The questionnaire was administered, for a third time, to 6 of the original 20 ex-MEC students during their 2008/2009 PGCE course. I analyzed the data on the changes in their beliefs as they experienced their first actual classroom teaching. There appears to have been hardly any change in the beliefs of these six students between the end of MEC and the half-way point in their PGCE. To put this in perspective; on average the six student's answers had moved 6.8 spaces along the Likert scale during the MEC in 2008 showing some change in beliefs, but only 0.2 spaces along the Likert scale following the MEC in 2009 showing very little change. This leads me to deduce that the changes in beliefs exhibited during the MEC phase of their education are robust to further change, at least in the short run.

I was also interested in a snapshot of what type of teaching the students were observing and undertaking at the time, during their PGCE. I wanted to see what style of teaching they were observing and taking part in. During the study with the six ex-MEC candidates, the participants were asked to comment on four statements. In addition, eleven direct-entry PGCE students were also studied. I asked all 17 participants to write out comments about the statements. The five or six quotations below each statement are taken directly from these comments and represent the spread of opinions in the whole group:

Statement A: I see maths teachers using didactic teaching methods in observations of maths lessons.

- 'Not true. Not in all lessons……lessons are more pupil led, rather than teacher led.'
- 'I have never observed this type of lesson….'
- 'Not all the time. Some do make an effort to make lessons interactive,'
- 'Half of the lessons (are like that) but I have seen….(some)…activities where there is pupil discussion.'
- 'I agree, but it isn't always true…….Main teaching is done using didactic teaching.'
- 'Generally, but SMART board instead of chalk-board.'

Statement B: I see a good range of teaching methods and strategies in observations of maths lessons.

- 'Yes, I saw (some) really interactive lessons…..pair-working, cards, mini-boards.'

- 'I strongly agree.'
- 'Yes I have observed many methods & strategies for teaching maths.'
- 'Not in all lessons but a few……group work is also taking place.'
- 'Yes. Not much group work……'

Statement C: I teach most of my lessons using basically didactic teaching methods.

- 'No. I was encouraged to encourage the classroom talk…..'
- 'No. I use many different methods…….'
- 'Yes……but a few tried card activities.'
- 'Sometimes.'
- 'I tried to implement activities where there was less chalk and talk…'
- '…I am trying hard to include more activities….I could be doing more……'

Statement D: I teach most of my maths lessons using a good range of teaching methods and strategies.

- 'I would like to but have not had the chance due to ICT issues at my school.'
- 'I have tried to do this….'
- '….I could do more.'
- 'I try.'
- 'Yes…..pure work & practice (with) discussions, feedback…..pupils working on the board or mini white-boards…..'
- 'Most times.'

I hope that these quotations open up a small window into what is actually going on within the classroom environment of Initial Teacher trainee's. According to the student teachers questioned, qualified classroom teachers do appear to be teaching in less didactic ways over a number of their observed lessons; this appears to contradict many Ofsted judgements and observations (Ofsted 2006, 2008). Statement A and B led to specific examples being cited by students but statement C and D generated few specific examples and occasional defensive statements. The vague nature of answers to statements C and D in comparison with the specific answers to statements A and B is very pronounced.

The comments appear to support the argument that there is less didactic teaching taking place in classrooms by qualified teachers than we are led to believe by government reports. In addition, the data appears to indicate that many trainee teachers whose 'beliefs' tend to be on the less didactic side of my Likert scale may not be translating their beliefs into actions in the classroom.

Future Findings

In addition to the work indicated above, I also interviewed four 'new' MEC students from the 2009 cohort to collect qualitative data. I undertook this data collection near the end of the course using a guided/semi-structured interview**.** Data analysis of this qualitative data is still in the early stages, however initial evidence indicates that there appear to be complex relationships between how students understand mathematics as

a subject, their own experiences of learning the subject at school and in Higher Education, their constructions of what kind of mathematics teacher they wish to be and their experiences of learning on the MEC. My initial findings tentatively indicate that the 'apprenticeship of observation' (Lortie 1975, 63) which students have undergone through their own learning in schools may also be a key factor here. Work on this data still continues.

Conclusions

Enhancement Courses are very important in today's ITE landscape. These courses and the ITE pre-learning which take place on them, as part of becoming a teacher, are an under-researched area. The whole area of *subject knowledge* has recently attracted political interest and it is important that as a profession we take the lead in figuring out which professional knowledge, and just as importantly which pedagogy, matters most for the effective teaching of mathematics. It is hoped that if this paper does nothing else it will stimulate dialogue in this area.

We know there is evidence that many teachers begin their careers with previously constructed, often naive, theories about teaching (Powell 1992). In fact Harel (1994, 115) notes, reflecting comments made by Thompson (1992), that: "teachers' beliefs of what mathematics is and, in particular, how it should be taught are tacitly formed by the way they are taught mathematics in their precollege and college mathematics education". I am still in the process of confirming these ideas with my research and measuring if these beliefs and hence future teaching pedagogies change during pre-ITE or ITE, but I have seen measurable change.

This research is limited by the size of the participation group. Small numbers are impossible to generalise from and therefore any conclusions I arrive at can only really be applied within the context of this small group of individuals.

The belief changes observed in my study need not be a function of the teaching on the MEC course and I am fully aware that the students may have been giving me answers they felt I wanted. Even if the belief changes observed in my study turn out to be a function of the teaching on the MEC course, I am now aware that the students may not be turning their beliefs into action in schools.

Despite the qualifying statements above, this paper demonstrates that I do appear to have some evidence to indicate that participation in a pre-ITE MEC, and hence exposure to a variety of teaching approaches, does change the 'beliefs' of pre-ITE students concerning the way in which they think mathematics should be taught and that change is robust, at least in the short run.

As practitioners in ITE and pre-ITE it is difficult to influence the way in which mathematics is taught to our students prior to their arrival on our Teacher Education courses. However, we do have an influence over the way that mathematics and particularly mathematics subject knowledge is taught on our ITE and pre-ITE courses. Maybe this is where the 'quality' of the mathematics teaching in this country could start to change.

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